The posterior approach for repair of popliteal artery aneurysms

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Objectives: **Ligation and bypass is the most commonly performed surgical treatment for popliteal artery aneurysm. This approach can be complicated by persistent collateral flow to the excluded aneurysm sac, which may lead to aneurysm growth, the development of compressive symptoms, and in some cases, rupture. Repair of popliteal aneurysms by posterior endoaneurysmorrhaphy and reconstruction with a short prosthetic interposition graft avoids these complications because patent collaterals communicating with the aneurysm sac are oversewn at the time of surgery. We report the early and mid-term outcomes of popliteal artery aneurysm repair using this posterior approach.**

Methods: **The records of all patients operated on for popliteal artery aneurysm from December 1981 to June 2003 were retrospectively reviewed. Patients who underwent popliteal artery aneurysm repair with a posterior approach were included in the study.**

Results: **From 1981 to 2003, 30 popliteal aneurysms (mean diameter, 3.2 cm; range, 1.9 to 6.2 cm) were repaired in 24 patients using a posterior approach with interposition prosthetic grafting. The median follow up was 21.5 months. Primary patency, primary assisted patency, and secondary patency were 92.2%, 95.8%, and 95.8%, respectively, at 1 and 2 years. The limb salvage rate was 100%.**

Conclusions: **Popliteal endoaneurysmorrhaphy using a posterior approach with interposition prosthetic grafting is simple, safe, and effective. The patency and limb salvage rates are equivalent to those obtained with ligation and vein bypass. In addition, the posterior approach eliminates the postoperative complications associated with persistent collateral flow into the aneurysm sac. (J Vasc Surg 2006;43:940-5.)**

The primary objective of popliteal artery aneurysm repair is to prevent thromboembolism, which can result in limb ischemia and limb loss. The secondary objective is to prevent aneurysm expansion and rupture. The most commonly performed surgical repair is proximal and distal aneurysm ligation with a saphenous vein bypass. The disadvantages of this technique include the possibility of continued aneurysm expansion from branch vessel backflow (type II endoleak), sacrifice of the saphenous vein, aneurysmal or occlusive degeneration of the saphenous vein graft, and wound complications from saphenous vein harvest.[1-9]

The senior author (W. S. M.) has routinely used a posterior approach for popliteal aneurysm repair, including a short interposition prosthetic graft, for reconstruction. The advantages of this approach include a short incision, complete interruption and defunctionalization of the aneurysm sac, and sparing of the saphenous vein. The objectives of this report are to describe the technique, document the early results, and report the patency and limb salvage rates after mid-term follow-up.

METHODS

Demographics. A review of the records from the University of California, Los Angeles, Medical Center from December 1981 through June 2003 identified 43 popliteal artery aneurysm repairs performed in 35 patients. Within this group, the posterior approach was used in 30 repairs in 24 patients. Not included in the study were 13 popliteal aneurysms that required repair with a medial approach. In 11 of the excluded cases, a medial approach was required because of extension of the aneurysm proximal to the adductor hiatus. In the two other excluded cases, there were no outflow vessels from the distal popliteal artery, which necessitated a distal vein bypass. Detailed analysis was limited to those patients whose aneurysms were repaired using the posterior approach with prosthetic interposition grafting.

Follow-up through April 2005 was obtained by reviewing institutional charts and surgeons' outpatient records after review and approval by our institution's office for protection of research subjects. Postoperatively, all repairs were followed with duplex ultrasonography scans, and graft patencies were calculated using the Kaplan-Meier life-table method.

Twenty-four men underwent 30 posterior reconstructions for popliteal artery aneurysm. The mean age was 67 years (range, 51 to 93 years). Comorbidities included hypertension (42%), coronary artery disease (33%), hyperlipidemia (33%), chronic obstructive pulmonary disease (13%), and diabetes mellitus (4%). Fourteen patients (58%) were smokers. Eighteen patients (75%) had bilateral popliteal aneurysms, and 13 patients (54%) had a concomitant abdominal aortic aneurysm. Eleven patients had other associated aneurysms comprising 12 iliac aneurysms, 3 femoral aneurysms, 3 thoracic aortic aneurysms, 1 superficial femoral artery aneurysm, and 1 subclavian artery aneurysm.

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Clinical features. Popliteal aneurysm size, proximal and distal extent, and distal runoff were assessed preoperatively with duplex ultrasound scans, conventional contrast angiography, or magnetic resonance angiography. In most cases, patients were evaluated preoperatively using duplex ultrasound alone. Eighteen limbs had three-vessel runoff to the ankle, seven had two-vessel runoff, and four had only one-vessel runoff. In one patient, preoperative imaging data for distal runoff were not available.

The average popliteal aneurysm diameter was 3.2 cm (range, 1.9 to 6.2 cm). Six aneurysms were thrombosed at the time of surgery. Nine patients had chronic symptoms, including local compressive symptoms in five, claudication in three, and ischemic rest pain in one. Two patients presented with acute thrombosis and limb threat.

All patients who had repair with the posterior approach underwent prosthetic interposition grafting. Dacron grafts were used in five patients and polytetrafluoroethylene (PTFE) grafts were used in 25. One patient required thrombectomy of the popliteal artery proximal and distal to the aneurysm, and two patients required thrombectomy of the trifurcation vessels. The two patients who presented with acute thrombosis and limb threat both underwent intraoperative thrombolysis.

Technical considerations. We preferentially use the posterior approach for repair of popliteal aneurysms. In preparation for a posterior approach, angiography or ultrasonography should be performed to ensure that the aneurysm does not extend proximally beyond the adductor hiatus. Aneurysms that extend proximal to the adductor hiatus should be repaired by using a medial approach to allow for adequate exposure of the proximal neck of the aneurysm. The trifurcation vessels can be well exposed by using the posterior approach. As long as at least one-vessel runoff from the distal popliteal artery is present, we perform a distal popliteal artery anastomosis for aneurysm repair. No tibial anastomoses were required in our series of posterior repairs.

Patients with thrombosis in the area of the popliteal trifurcation may not be amenable to repair using the posterior approach. In our series, two patients underwent thrombectomy of the trifurcation vessels followed by graft anastomosis to the distal popliteal artery. Two other patients who presented with thrombosed popliteal aneurysms and no patent outflow vessels from the distal popliteal artery, but with reconstitution of a single vessel more distally in the leg, required distal vein bypass and were not included in the present series.

Anesthesia can either be regional or general endotracheal anesthesia. The patient is positioned prone on the operating table with the knee slightly flexed. The posterior thigh, popliteal fossa, and calf are appropriately prepared and draped. We prefer to use a vertical incision placed over the aneurysm across the popliteal fossa instead of an S-shaped curvilinear incision. We have observed no problems with postoperative healing or wound contracture with the use of this incision.

The sural nerve and lesser saphenous vein should be identified and protected. The deep fascia is incised for the length of the incision. The tibial nerve and common peroneal nerve are identified and carefully mobilized. Although nerve injury is a potential complication of the posterior approach, no nerve injuries occurred in the present series.

A perivascular dissection plane is entered on the surface of the aneurysm, taking care not to injure an adherent popliteal vein. Dissection is carried proximally toward the adductor hiatus until the neck of the aneurysm is encountered. The popliteal artery is then circumferentially mobilized for proximal control. If necessary, the adductor hiatus can be incised to gain more proximal exposure. The dissection is then carried distally to the end of the aneurysm, and the popliteal artery is then circumferentially mobilized for distal control. More distal dissection can be used to expose the proximal anterior tibial artery and the tibioperoneal trunk, if required. The patient is then systemically heparinized. We usually use a dose of 3500 IU of sodium heparin.

The popliteal artery is clamped proximally and distally. The aneurysm sac is opened, and thrombus is evacuated. Several backbleeding geniculate arteries will usually be present that can be controlled within the sac by using suture ligature. The popliteal artery is then divided proximally and distally.

A graft is selected. This can either be an 8.0-mm knitted Dacron prosthesis or a 6.0-mm to 8.0-mm PTFE graft. Proximal and distal anastomoses are constructed with 5-0 proline in a continuous manner. The graft is positioned within the bed of the aneurysm. The graft length should be kept as short as possible, but not under tension. We perform prosthetic grafting preferentially when the posterior approach is used, even in patients with only one- or two-vessel runoff; however, a vein bypass could also be performed if desired. The incision is then closed and a dressing is applied. The patient may ambulate the following morning, and most patients can be discharged by the third postoperative day.

RESULTS

The 30-day primary patency rate was 100%. The average length of hospital stay was 3.3 days. In the postoperative period, two local wound complications occurred, one hematoma and one seroma, both of which were successfully drained percutaneously. The median follow-up time was 21.5 months. Duplex ultrasonography was used to assess postoperative graft patency. Graft patencies were calculated using the Kaplan-Meier life-table method. At 2 years, the primary patency, assisted primary patency, and secondary patency were 92.2%, 95.8%, and 95.8%, respectively. Limb salvage was 100% for the full duration of the follow-up period.

One graft thrombosis occurred at 11 months. No intervention was undertaken because the patient was asymptomatic. Two patients required angioplasty, one at 4 months after repair and one at 27 months. The patient who underwent angioplasty at 4 months after repair had presented with a thrombosed aneurysm and distal propagation

of clot requiring thrombectomy of the trifurcation vessels and a vein patch angioplasty of the distal popliteal artery and tibioperoneal trunk. The angioplasty was performed for a stenosis at the site of the vein patch angioplasty. A fourth patient required revision of the proximal anastomosis for aneurysmal degeneration of the proximal superficial femoral artery at 54 months postoperatively.

DISCUSSION

The surgical treatment of popliteal artery aneurysms has a long history. In the second century AD, Antyllus, a Greek physician, performed proximal and distal arterial ligation followed by evacuation of the aneurysm sac.[10] A variety of extirpative techniques were subsequently described until, in 1785, John Hunter performed arterial ligation at the adductor canal for the treatment of a popliteal artery aneurysm.[11] Proximal ligation subsequently became the preferred technique for the treatment of aneurysms, and this approach became known as the Hunterian method.

In 1888, after an unsuccessful initial attempt to treat a brachial artery aneurysm using proximal ligation, Rudolph Matas performed an additional distal arterial ligation, opened the aneurysm sac, and oversewed its patent collaterals.[12] After Matas's description of endoaneurysmorrhaphy, later techniques incorporated either aneurysmorrhaphy or aneurysm resection as an integral part of the surgical treatment of popliteal artery aneurysm.[13-15] Resection of the aneurysm sac, however, was sometimes complicated by injury to the tibial nerve and the popliteal vein.

Sterling Edwards described the technique of exclusion and saphenous vein bypass in 1969.[16] The advantages of this technique included a reduced risk of nerve or vein injury as well as decreased postoperative pain.[16] This has now become the most frequently performed surgical approach to popliteal artery aneurysms.

The primary and secondary patency rates reported in our series are comparable to the best results reported for ligation and bypass. This may in part reflect the good distal runoff observed in most of our patients. Although six presented with thrombosed popliteal aneurysms and two with acute thrombosis, 25 (83%) of 30 patients had two- or three-vessel runoff to the foot. Several series have reported superior patency rates in limbs with two- or three-vessel outflow,[17-22] and some authors have found that better outflow is correlated with a higher limb salvage rate as well.[17,21]

In contradistinction, multiple authors have reported that ligation and prosthetic bypass grafting has a lower patency rate than ligation and vein bypass.[17,20,23-25] In comparing 20 prosthetic repairs with 80 vein bypasses, Bourriez et al[25] reported a 94% 2-year primary patency for vein bypass compared with a 62% 2-year primary patency for prosthetic bypass. Our 2-year primary patency rate of 92.2% is comparable to that observed for saphenous vein bypass and is markedly superior to previously reported PTFE bypass patencies. We believe that the shorter length of prosthetic graft required for a posterior repair may decrease its thrombogenicity in this application. Previously, Blanco et al[20] demonstrated that short-segment PTFE bypasses had patency superior to that of long-segment PTFE bypasses for the treatment of popliteal artery aneurysm.

Advantages of prosthetic grafts include the elimination of complications commonly observed in vein grafts such as aneurysmal degeneration and mid-graft intimal hyperplasia.[3,9] Additional benefits of prosthetic repair derive from the avoidance of saphenous vein harvest, shortening procedure time, and decreasing potential wound complications.

Our 2-year primary patency rate of 92.2% is comparable to the best results reported for ligation and vein bypass. In two recently published series, Bourriez et al[25] found a 2-year primary patency rate of 94% in a series of 80 venous bypasses, and Mahmood et al[26] reported a 2-year primary patency rate of 73% in a series of 52 treated limbs. Unfortunately, because many of our patients are referred from outside centers, long term follow-up remains an ongoing challenge. Because the median follow-up in our series was only 21 months, it is difficult to make direct comparisons beyond this time point.

Several series reporting popliteal aneurysm repair with ligation and vein bypass have reported excellent primary patency rates over longer follow-up periods. Aulivola et al reported[24] a 5-year primary patency rate of 90% in a series of 46 vein bypasses, and Upchurch et al[27] reported a 5-year primary patency rate of 92% in a series of 60 vein bypasses. Because of the shorter duration of follow-up in our series, we cannot conclude that the patency of prosthetic grafting using a posterior approach is equivalent to that obtained with ligation and vein bypass over these longer time periods.

When compared with endovascular popliteal aneurysm repair, however, the posterior approach with prosthetic interposition grafting is superior. Early graft thrombosis remains a significant problem after endovascular repair of popliteal aneurysms.[28-30] Stent migration and breakage are also significant concerns.[31] In the five largest series reported to date, 1-year primary patency ranged from 47% to 87%.[28-32] At 2 years, Henry et al[28] reported a primary patency of 58% in a series of 12 repairs, and Tielliu et al[31] reported a primary patency rate of 77% in a series of 57 repairs. Furthermore, because stent-graft repair requires a substantial length of proximal and distal neck for secure fixation, we doubt that this technique is as generally applicable as the posterior approach. Although endovascular grafts and techniques will assuredly improve in the future, at the current time, open surgical approaches remain superior.

The greatest advantage of the posterior approach for popliteal aneurysm repair is that patent collaterals leading into the aneurysm sac can be easily identified and oversewn at the time of surgery. Because ligation and bypass does not interrupt the collateral circulation, popliteal artery aneurysms can remain patent and are at risk for postoperative expansion. Even thrombosed aneurysms can continue to grow after ligation and bypass, and patent geniculate col-

laterals in communication with thrombosed aneurysm sacs have been identified using ultrasonography.[3] In four recent retrospective studies, popliteal artery aneurysm patency after repair with ligation and bypass ranged from 6% to 48%, and aneurysm growth was identified in 22% to 33% of patients.[3-6]

Continued aneurysm patency and aneurysm growth can lead to nerve and vein compression, distal embolization, and rupture. In a study of 36 popliteal artery aneurysms treated with ligation and bypass, Kirkpatrick et al[4] reported that five patients required reoperation. One patient presented with distal embolization, one presented with rupture, and compressive symptoms developed in three others because of aneurysm enlargement. In each case, a patent geniculate collateral was found at exploration. In a series of 26 patients, Mehta et al[5] reported that reoperation was required in three patients who presented with aneurysm rupture and in three others who presented with compressive symptoms due to aneurysm expansion. At the time of exploration, intrasac pressure measurements were made in four patients, and in all cases, near systemic pressures were measured.

Although the problem of continued popliteal artery aneurysm growth after ligation and bypass was first reported by Flynn and Nicholas[1] in 1983, it has only recently received more detailed attention. Based upon the reports of Kirkpatrick et al, Mehta et al, and others,[3-6] we believe that this phenomenon is more common than previously realized. Recognition of this problem may have been delayed partly because postoperative duplex imaging to assess vein graft patency does not require visualization of the aneurysm sac; therefore, many excluded popliteal aneurysms that remained patent or increased in size were likely unidentified.

Since Edwards' initial description in 1969, exclusion and saphenous vein bypass has become the most common approach for the surgical treatment of popliteal artery aneurysms. Implicit in the widespread adoption of this technique was the belief that obliteration of the collateral circulation to the aneurysm sac, as advocated by earlier authors, was unimportant and that the natural history of excluded popliteal aneurysms was innocuous. Although the long-term patency of saphenous vein bypasses has been excellent, recent reports call into question the durability of this repair.

Multiple reports have documented continued patency of popliteal aneurysms after ligation and bypass and postoperative increases in the size of both patent and thrombosed popliteal aneurysms. This continued growth can lead to the development of new symptoms requiring reoperation, including nerve and vein compression, distal embolization, and rupture.

CONCLUSION

We believe that the posterior approach for repair of popliteal artery aneurysms is superior because it has excellent patency and prevents further aneurysm expansion by completely interrupting the collateral circulation to the aneurysm sac.

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AUTHOR CONTRIBUTIONS

Conception and design: WSM, BDB
Analysis and interpretation: WSM, BDB
Data collection: BDB
Writing the article: WSM, BDB
Critical revision of the article: WSM, BDB
Final approval of the article: WSM, BDB
Statistical analysis: JG
Obtained funding: WSM
Overall responsibility: WSM

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DISCUSSION

DR. BURNAND: I think everyone has their own feelings about popliteal aneurysms, and when you look at the abdominal aortic aneurysm the data is extremely good. When you get out to popliteal aneurysms, the data is very nonclear-cut as to what you should. What we don't seem to take into account when operating on popliteal aneurysms is the amount of thrombus burden that is actually present within the aneurysm sac. I wonder whether you'd actually looked at that in terms of selecting your cases. The posterior approach is fine for the size of aneurysms that you have mostly shown us. The problem is, as has been alluded to already, for those aneurysms that go above. In the last month, I've done three cases where it looked fine but actually there was a lot more disease going up into the Hunter's canal. So we come from the medial side. Like you, we believe that the collateral should be ligated because I've had unpleasant experiences of aneurysms getting to about this size in the popliteal fossa with the bypass stretched over the top of them. You can divide the medial head of gastrocnemius. You can open the sac and you can still ligate the collaterals from within it if you come from the medial side, so I think the posterior approach has to be selected for those aneurysms that you are sure are not going too high and too low. In my experience that's quite difficult to gauge from beforehand. In addition, if you come from the medial side this long saphenous vein is just sitting there waiting to be placed into it, so I'd be unconvinced that I am going to routinely come from posteriorly and I don't agree with you that that horrible scar down the middle of the popliteal fossa doesn't occasionally cause problems.

DR. BESETH: Thank you very much for your comments. I think that certainly it's true that the anatomic extent of the popliteal artery aneurysm should be known ahead of time and the limitations you point out are certainly correct. I think that given that you do obliterate or interrupt the collateral flow to the popliteal aneurysm sac, I think that the approach that you describe—I think that would be a very helpful modification to ligation and bypass without interruption of that collateral flow.

DR. LAWRENCE: My question has to do with conduit. You show in your operative images that you had to move the lesser saphenous vein aside to approach the popliteal artery. In what situations would you consider using a lesser saphenous as the conduit? In my experience, the lesser saphenous is close to the size of the popliteal artery, so it takes no more time to put in a short segment lesser saphenous than a prosthetic graft. Then you have an all-autogenous, as opposed to a prosthetic repair. So when do you consider using the lesser saphenous vein?

DR. BESETH: In general we use a prosthetic graft with this approach and the results have been such that we haven't felt the need to necessarily go to a vein bypass. I think one of the things that I'd also like to note is that with vein bypass and in series of popliteal artery aneurysm treated with exclusion, vein bypasses do develop on occasion aneurysms or other types of problems, and we feel that actually prosthetic graft may be superior to a vein in this approach and in this location. But certainly you could use a vein bypass with this approach, but we have not done that.

DOCTOR: A comment and a question. Regarding the use of autogenous vein for popliteal aneurysm, did you look at the incidence of aneurysmosis of either saphenous vein or arm vein which we reported a long time ago. The association of an aneurysm in a vein graft is virtually limited to patients who have aneurysmal disease not only in the leg but also in the heart, so there can be a case made for using prosthetic material but the incidence is so small that I would not hesitate to use an autogenous vein.

My question is this: do you think that using the medial approach eliminates the ability to open, evacuate the aneurysm and oversew it? We do that routinely. We no longer use the ligation technique. We use the medial approach. We open all aneurysms. We oversew the branches, and then we do the standard Sterling-Edwards approach. What do you think of that?

DR. BESETH: Thank you. I think that's an excellent approach. I think that at least based upon my reading of the literature that approach is not the approach that is most commonly used. On reading the literature and recent reports, I think the majority of popliteal aneurysms treated with a medial approach are still treated with ligation and bypass without a defunctionalization of the aneurysm sac. I think that if you do that, if you interrupt the collateral flow, then I think that is a much better procedure than simply ligation and bypass.

DR. GIBSON: Thanks for the paper. One problem often with these aneurysms is when they thrombose they take out the outflow. Were any of these patients treated with thrombolysis first, and what's the role for thrombolysis in making a better outflow target for this procedure?

DR. BESETH: Thank you. In our series, the two patients who presented with acute thrombosis were treated with intraoperative thrombolysis. There have been two recent papers dealing specifically with the issue of thrombolysis preoperatively for patients presenting with acute thrombosis, and I think that it has been the experience of those authors that preoperative thrombolysis has greatly improved the limb salvage rate with that procedure.

Of note also, I think that's one of the big differences; if you look at older papers and papers in the modern era, the advent of thrombolysis has really improved limb salvage rates and in fact there are some authors in recent series who have reported similar outcomes for patients who were acutely symptomatic and patients who were asymptomatic which I think really is a credit not only to surgical technique but also to the use of thrombolysis.

DR. ANDERSEN: We've had a real interest in the posterior approach and have used it almost exclusively for our popliteal entrapment patients. In those patients with popliteal aneurysms, we found a very limited use strictly because of the anatomy. Although it is a nice approach, we've found that the majority of patients were not candidates. You say it's your preferred approach. I would like to know the exact percentage of patients that you approach posteriorly.

Another question. We routinely use more of a lazy-S approach posteriorly. Can you comment on your incidence of wound complications using a strictly vertical approach?

And then the third question, using this limited approach, have you had any cases with progression of aneurysmal disease, either proximal or distal the your limited repair?

DR. BESETH: Those are excellent questions. Thank you. As for the incision, primarily a vertical incision is used; however, some surgeons at our institution do use a lazy-S approach. We have not had any problems with contractures following the vertical incision, although I know that the lazy-S approach is preferred by many.

The only wound complications that we had in the series were the seroma and the hematoma that I described.

In terms of progression of disease, we did have one patient who required a revision of the proximal anastomosis 4 ½ years following a posterior repair, and this was a patient who developed further aneurysmal change of the SFA proximal to the previous repair.

Regarding the percentage, I can't give you an exact number. I can tell you that the vast majority of patients at our institution are treated with the posterior approach. Generally we limit the medial approach to patients who have extent of disease that is not amenable to a posterior approach or who require bypass grafting to a tibial vessel, and for that we prefer vein.

DR. WEINSTEIN: I enjoyed your presentation.

The question I wanted to ask was asked earlier but I'm not sure you really answered it. What are your indications for fixing asymptomatic popliteal aneurysms? In our experience with the majority of these patients being quite elderly, we tend towards conservatism. These patients have their run-off evaluated by duplex scan and if they have good two-vessel run-off and the aneurysm is <2.5 cm, we tend not to operate upon them. If there is evidence of thromboembolism, even in the absence of symptoms, we consider these patients for surgery. I wonder if you can comment on that.

DR. BESETH: Thank you. That varies somewhat from surgeon to surgeon. I think in general most surgeons at our institution would have about 2 cm as sort of entry level criteria in terms of size criteria the smallest aneurysm treated in our series was 1.9 cm. I think that as you point out a preoperative duplex evaluation is very important and I think that patients who do have a significant thrombus burden, that would make us more likely to operate in patients who as you say may not be ideal operative candidates. If they do have a large amount of thrombus burden or they do have evidence of past embolization or poor outflow that may make us more like to operate in those types of patients.